Defense Technical Information Center Compilation Part Notice

ADP014968

TITLE: Improvement in the Performance by Changing Electrode Shape in Barrier Discharge Type ESP

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: International Conference on Phenomena in Ionized Gases [26th] Held in Greifswald, Germany on 15-20 July 2003. Proceedings, Volume 4

To order the complete compilation report, use: ADA421147

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP014936 thru ADP015049

Improvement in the Performance by Changing Electrode Shape in Barrier Discharge type ESP

Hideyuki Ando[1)], Yosuke Kuroda[1)], Yoshihiro Kawada[1)], Takeo Takahashi[1)], Yoshiyasu Ehara[1)], Tairo Ito[1)], Akinori Zukeran[2)], Yoshihiro Kono[2)], Kouji Yasumoto[2)]

1) Musashi Institute of Technology,1-28-1,Tamazutsumi,Setagaya-ku,Tokyo 158-8557,Japan
2) Fuji Electric Co.Ltd.,1-11-2,Osaki, Shinagawa-ku, Tokyo 141-0032,Japan

In general corona discharge is used in ESP (Electrostatic Precipitator). The corona discharge type ESP can remove DEP (Diesel Exhaust particles) at high collection efficiency but at low removal efficiency for NOx and re-entrainment phenomena due to low resistivity and particle agglomeration on the electrode. Barrier discharge is effective for removal NOx. Therefore, we are used Barrier discharge in ESP. In this paper, we investigated the plate type, punched hole type, and grid type electrode. As results, energy efficiency of particle collection becomes high with punched hole and grid type electrode than with plate type electrode. And then, punched hole type achieved high collection efficiency as comparison with plane type electrode at the same power consumption.

1. Introduction

The electrostatic precipitator (ESP) has been used extensively to decontaminate polluted gases and to clean air because of high collection efficiency. One of the major tasks of ESP applications is to increase visibility and to clean the air in the highway tunnels. The conventional ESP eliminates suspended particles traceable to diesel exhausted particle. ESP with DC corona discharge precharger little removes NOx[1]. Therefore, we propose barrier discharge type ESP to remove particles and NOx simultaneously. Barrier discharge is effective for removal NOx. Barrier discharge type ESP has been investigated to remove suspended particles [2]. The aim of this study is to improve energy efficiency for particle collection and NOx removal with several electrode shapes. This present version electrode shapes are changed from plane to punched hole, to grid pattern type. Several electrode shapes become the change of barrier discharge condition.

2. Experimental Methods

The schematic experimental system is shown in Fig.1. Particle generated by the diesel engine. The diesel exhaust gases is diluted with air in the mixing chamber, and then boosted through the duct and enter to ESP. The gases cleaned by ESP pass through the induced fan and then exhausted. The mean gas velocity in the duct is 1.5m/s constant in all test condition. The number density of suspended particle is measured by the particle counter (PC, RION KC-01C, measured particle size d > 0.3μm). The sampling locations are upstream and downstream of the ESP. This present version ESP is barrier discharge type. The barrier discharge type ESP electrode configuration is shown in Fig.2. These barrier discharge electrodes are the aluminum plate (0.5mm thick) sandwiched by two glass plates (0.5mm thick), electrode length is 45mm(aluminum), and 65mm(glass plate). In here, 3 varieties of aluminum plate electrode shapes are used as illustrated in Fig.3. The punched hole type electrode has many holes, The diameter of a hole is

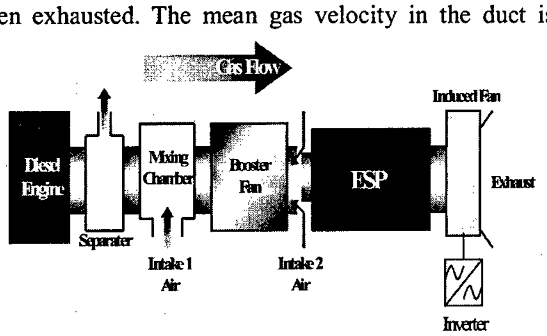


Fig.1 Schematic diagram of experimental system

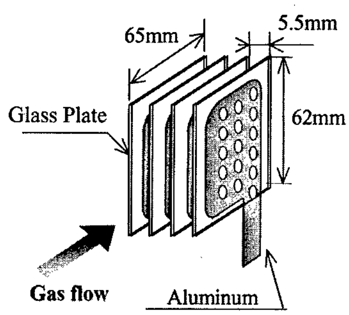
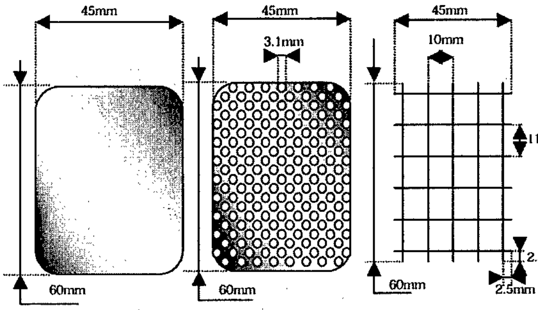


Fig.2 Electrode configuration of barrier discharge type electrostatic precipitator.



a)Plane b)Punched hole (ϕ3.1mm) c)Grid Pattern

Fig.3 Test shapes of aluminum plate electrode

3.1mm. The grid pattern type electrode consists of tungsten wire with 0.26mm diameter, these wires are laid out such as grid pattern. These aluminum plate electrodes are applied high voltage (AC50Hz). The discharge power is measured by the Lissajous figure (V-Q plots) on oscilloscope.

3. Results and Discussion

Discharge current for several electrode shapes as a function of applied voltage is shown in Fig.4. At the same applied voltage, discharge current at punched hole type becomes high, discharge current at grid pattern type becomes low as compared with plane type electrode. As for gird pattern type electrode, discharge current becomes low due to decrement of the electrode area. Electric field intensity distribution as the punched hole type electrode is shown in Fig.5. This figure is analyzed with ANSYS 6.0 (Ansys Inc. Electric field analysis with a finite-element methods). The electric field intensity at edge of punched holes type electrode is 1.2 times stronger than at plane type electrode. Especially, electric field intensity around the punched hole becomes high. Hence, because of this field intensity increment, discharge current at punched hole type electrode becomes high as shown in Fig.4.

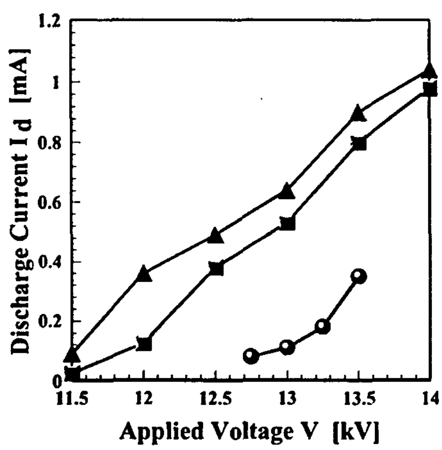


Fig.4 Discharge current as a function of applied voltage. Plots indicate electrode shapes ;
■:Plane type , ▲:Punched hole type,
●:Grid pattern type electrode.

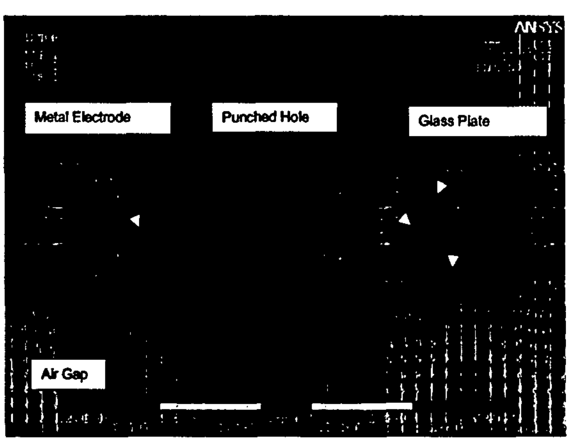


Fig.5 Electric field intensity distribution as the punched hole type electrode

Discharge power as a function of collection efficiency is shown in Fig.6. Collection efficiencies at punched hole type and grid pattern type electrodes become high in comparison with plane electrode. Additionally, collection efficiency increases up to 95 percent with increasing discharge power at punched hole type. It has been shown that energy efficiency for particle collection is improved when deference in electric field intensity exists in barrier discharge.

4. Concluding Remarks

Energy efficiency for particle collection is tested by changing barrier discharge electrode shape. Consequently, it has been shown that energy efficiency for particle collection is improved when the difference in electric field intensity exists in barrier discharge area. Additionally, using punched hole type electrode achieved high collection efficiency as comparison with plane type electrode at the same power consumption.

We would like to thank Mr. T.Nakahara and Dr. H.Kishida at Musashi Institute of Technology for their valuable comments and discussion.

5. References

[1]K.Ohtuka et al "Oxidation Characteristics of Nitrogen Monooxide in Corona Discharge Field"(In Japanese), Proc. Inst. Electrostatics Jpn., Vol.9, No.5, pp.346-325 (1985)

[2] Y.Kawada et al "Particle agglomeration on the electrodes in electrostatic precipitator with barrier discharge system"Xth Asian Conference on Electrical Discharge, Kyoto Japan (2000)

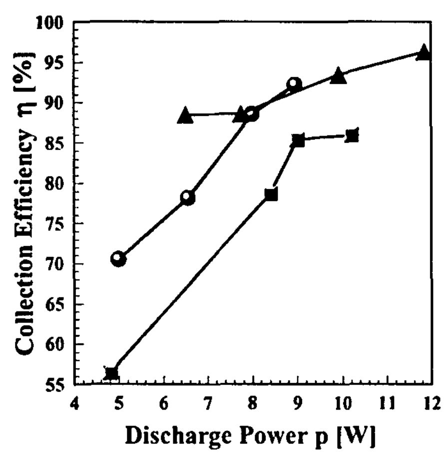


Fig.6 Collection efficiency for several electrode types as a function of discharge power.
■:Plane type , ▲:Punched hole type,
●:Grid pattern type electrode.